# CORN GLUTEN FEED IN WINTER SUPPLEMENTS

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ABSTRACT

The objective of this study was to test the feasibility of using corn gluten feed in winter supplements. For this study, 60 unbred Rambouillet ewes were randomly assigned to one of twenty pens. Additionally, pens were assigned to one of four treatments. Treatments consisted of the control diet of only hay and three treatments containing corn gluten feed at 0, 10, and 30% for 60 days. No difference was observed in supplementation refusals or intake among treatments. Mean body weights within all treatments did differ ($P<0.05$) by date. Mean body weight within each individual treatment were similar ($P>.05$) among treatments. Treatment by day interaction differed ($P<0.05$). The 30% treatment better maintained and increased body weight over the 10 % group as well as the 0% treatment and control all while having a lower mean body weight by treatment although mean body weight by treatment did not differ ($P>0.05$).

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# INTRODUCTION

One of the largest expenses of the livestock industry is the cost of feed, particularly supplemental feed (Holechek and Herbel 1986). Feed accounts for 50% to 75% of total production costs in the livestock industry, making it one of the largest expenses for producers (Kellems and Church 2002). Ingredients, like corn, continue to be cost prohibitive because of demand due to human consumption, industrial uses and ethanol production (Rattray 2012). Today's high demands are compounded with supply fluctuations caused by environmental conditions such as drought that results in higher feed costs because of limited supply and decreased feed availability (USDA 2012). Therefore, it is becoming more important for producers to understand the potential value of utilizing byproducts in feed programs (Kellems and Church 2002).

Corn gluten feed (CGF) is a byproduct of the corn milling industry and is the product of wet milling corn for the production of artificial sweeteners, such as high fructose corn syrup (Ham et al. 1995; Schroeder 2010). Corn gluten feed has been utilized in the dairy industry, where it is considered an excellent feedstuff (Blasi et al. 2001; Schroeder 2010). Corn gluten feed prices are favorable compared to grains and protein sources making them ideal for the reduction of feed cost within the livestock industry (Myer and Hersom 2008).

As Samuelson (2013) indicated, feedlot lambs readily consume a diet consisting of 30% CGF. Average daily gain (ADG) was similar among treatments consuming 0, 10, and 30% CGF, while feed efficiency tended to be higher for lambs consuming a diet with higher proportions of CGF (Samuelson 2013). Based on these results, this study assesses the CGF in winter supplemental diets feed to ewes.

# OBJECTIVES

The objective of this study was to determine the feasibility of using corn gluten feed in winter supplements for sheep.

## LITERATURE REVIEW

Corn gluten feed (CGF) is a byproduct of a process within the corn milling industry known as wet corn milling (Blasi et al. 2001). Corn milling produces corn gluten as a byproduct for the production of artificial sweeteners such as high fructose corn syrup (Ham et al. 1995).  The milling process consists of preparation and steeping, germ separation, grinding, screening, and starch separation and conversion (Blasi et al. 2001). The product of the milling process are gluten meal, gluten feed, corn germ meal, corn oil, and condensed fermented corn extracts (Blasi et al. 2001). Corn gluten feed is then produced by combining corn bran with steep liquor, which can produce two different forms (Myer and Hersom 2011). These two different forms of CGF are wet corn gluten feed (WCGF) and dry corn gluten feed (DCGF) (Hoffman 1989).

Dry Corn Gluten Feed is produced specifically by combining corn bran and steep liquor, occasionally corn germ meal depending on the facility, which is then dried and passed through a hammer mill, and then pelleted (Blasi et al., 2001). Wet Corn Gluten Feed (WCGF) is produced by pressing wet corn bran and then combining the pressed corn bran with corn steep liquor (Blasi et al. 2001).  Overall, WCGF and DCGF are comparable to corn in nutrient content as seen in Table 1 (Blasi et al., 2001).

Ham et al. (1995) indicated that nutritionally WCGF was superior to DCGF. Although, WCGF is a quality product it is not a practicable option on most ranches because it has to be fed within10-14 days to prevent spoilage (Hoffman 1989).  Wet Corn Gluten Feed molds and causes other undesirable fermentation that may reduce intake (Blasi et al. 2001; Hoffman

Table 1. Average nutrient content comparison of corn, wet corn gluten feed (WCGF) and dry corn gluten feed (DCGF).

| Nutrient Content | Dry Matter | Crude Protein | TDN | Fat | Crude Fiber | Total Starch |
|---|---|---|---|---|---|---|
| | | | ---%--- | | | |
| Corn | 88 | 10.1 | 90 | 4.2 | 2.2 | 72 |
| WCGF | 42-44 | 14-22 | 90 | 3.0-5.0 | 7.0-8.4 | 26 |
| DCGF | 90-92 | 21-22 | 78 | 2.0-3.3 | 8.0-8.4 | 18 |

Originally presented by - Blasi et al. (2001) p. 4

1989). Dry Corn Gluten Feed is the more viable option because it is pelleted, allows it to be easily stored and transported, thus allowing it to more cost effective and an effective alternative feed source (Schroder 2012; Samuelson 2013).

Schroeder (2010) demonstrated that CGF can be fed up to 30% in a sheep diet and can serve as the sole grain and protein source for cattle. Dry Corn Gluten Feed can replace 50% of the grain in the diet. Dairy industry; managers who have replaced 100% of grain with sources of DCGF, observed no negative effects on overall performance (Hoffman 1989). Therefore, CGF can replace a portion of grains, decrease the need for additional protein sources, and reduce feed cost (Noble Foundation 2012).

Corn Gluten Feed is an excellent source of energy and protein and is comparable to corn in total digestible nutrients (TDN). Dry Corn Gluten Feed has a TDN value of 75-83 % where corn has a TDN of 88-90% (Myer and Hersom 2008). The difference between corn and CGF is that energy in corn comes from starch where energy in CGF comes from digestible fiber (Myer and Hersom 2008). The protein content in DCGF is relatively high at 22% crude protein were as corn is typically 9-10% crude protein (Blasi et al. 2001). Corn Gluten Feed also has a high ruminally degradable protein fraction and appears to be degradable to upwards of 70% in DCGF and 75% in WCGF (Schroder 2012). This allows WCGF to be more digestible than DCGF and permits WCGF intake to be greater that DCGF (Schroder 2012).

Given that CGF is relatively high in protein and energy, it can be supplemented to livestock grazing low to moderated quality forage (Blasi et al. 2001). In other words, CGF would make an excellent supplement during the winter months when forages are low to moderate in quality and provide inadequate protein or energy. Additionally, feeding corn leads to reduced forage intake and decreased fiber digestion. This is due to changes in rumen microbe populations that favor starch over fiber, which reduces fiber digestion (Blasi et al., 2001). Therefore, supplementing CGF over corn may increase the digestibility and intake of forages or native grass hay because energy in CGF originates from digestible fiber and should not result in a shift in rumen microbial populations.

In addition to being highly digestible, CGF has shown ability to provide and meet the energy and nutrient demands for optimum growth in heifers (Blasi et al., 2001; Schroder 2010). Corn Gluten Feed's high fiber content successfully replaced the roughage in a growing diet when fed at 40% dry matter (DM) of the diet (Blasi et al., 2001).

Economically, CGF is an excellent substitute for protein in a grain or forage mix (Schroder 2010). It has been shown that CGF is profitable to feed and makes rations containing CGF economically feasible (Haugen and Hughes 1997). It has also been shown that CGF is a viable source of nutrients and a possible option to replace grains fed for supplementation during the winter months (Blasi et al. 2001). It may decrease overall input cost but continue to maintain productivity of livestock. Unfortunately, most of the information available is based on cattle as the experimental unit. Thus, little information exists on how other ruminants will respond to CGF in the diet.

## MATERIALS AND METHODS

This study was conducted at the Angelo State University Management, Instruction, and Research (MIR) Center in San Angelo, Texas during the summer months of July, August and September of 2014. Prior to the study, ewes were grazed on native rangeland, on the MIR Center and had *ad libitum* access to fresh water and Calcium/Phosphorus rangeland mineral. Rambouillet ewes (n=60) were randomly assigned to one of four treatments (15 ewes/treatment). Ewes were a minimum of one year of age and not bred.

The study was conducted in a pen situation. All 20 pens had identical dimensions of 3.0 m wide and 8.9 m deep. Ewes were randomly assigned to one of four groups by ear tag number with three animals per pen (n=3) and five pens per treatment. Each pen had *ad libitum* access to fresh water and Sudangrass hay to simulate winter rangeland forages. The treatments included three different rations that mimicked a 30% crude protein range supplement. Thus, supplements were isonitrogenous (30% protein) that contain 0, 10, or 30% CGF. Therefore, the treatment diets were the base diet comprised of only hay (control), 0% corn gluten ration, 10% corn gluten ration, or 30% corn gluten ration (Table 2).

Corn gluten feed was purchased directly from Palmer Feed & Supply in San Angelo, Texas and all feed was mixed in the Angelo State University feed mill. In the 10 and 30% rations, corn gluten replaced Alfalfa pellets, Cottonseed meal, and Corn but contained the same nutrient content as 0% ration (Table 2). The feeding trial lasted for 60 days and supplementation and distribution of the 0, 10, and 30% rations occurred at a rate of 1,028 grams per pen per day thrice weekly on Mondays, Wednesdays, and Fridays.

Table 2. Ingredients (as fed basis) and nutrient content for supplemental treatments

| Ingredient | Percent (as fed) | | |
|---|---|---|---|
| | 0 | 10 | 30 |
| | | ---%--- | |
| Corn gluten feed | -- | 10.0 | 30.0 |
| Milo | 19.1 | 23.6 | 10.6 |
| Cottonseed meal | 62.5 | 61.2 | 54.2 |
| Alfalfa | 13.2 | -- | -- |
| Molasses | 5.0 | 5.0 | 5.0 |
| Premix | 0.2 | 0.2 | 0.2 |
| Nutrient Content | | | |
| Dry Matter | 90.2 | 90.8 | 93.3 |
| Crude protein | 30.1 | 30.0 | 30.0 |
| MEt Energy (kcal/kg) | 778.3 | 795.0 | 357.9 |
| Fiber | 10.6 | 10.3 | 15.0 |
| Total Digestible Nutrients (TDN) | 68.9 | 70.2 | 69.4 |

On day 22, supplementation and distribution was increased from thrice weekly to daily feeding Mondays thru Fridays and lasted through the remainder of the study. Additionally, ewes were treated on day 5 with Ivomec® at a rate of 11.8 kg per kg body weight.

Refused feed (supplement) was collected and weighed exactly one hour after distribution.  Ewes were weighed every 14 days and were weighed on days -9, 5, 19, 33, 47, 61.

The cost of the feed was also evaluated and the cost analysis was based on current market feed costs of ingredients at the end of the study, and prices were provide by Palmers Feed & Supply in San Angelo, Texas. In addition, subsamples of supplements and hay were collected. Three random hay samples were collected on days 12, 31, 43 and 59. Additionally, three random samples were taken of each treatment group on days 11, 43 and 59. All samples were then stored at -80°F for nutritional analysis. Upon completion, hay and supplement samples were composited and sent to Dairy One, Ithaca, New York for dry matter, crude protein, digestible protein, net energy for maintenance (kcal/kg), neutral detergent fiber (NDF), acid detergent fiber (ADF) and total digestible nutrients (TDN).

Average weight and intake were analyzed using repeated measures analysis of variance as a completely randomized design with individual animals nested within treatments as the experimental units and treatments serving as the main effect. For analysis of intake, the experimental model was the same except that pens nested within treatments served as replications. Means were separated using Tukey's HSD when $P<0.05$. The comparison of weights used, ewe initial weight as a covariate to account for variations among individual ewes. Cost data and nutritional quality data were compared among treatments by calculating treatment means. All data was analyzed using the statistical software JMP (SAS Institute 2007).

## RESULTS

Based on comparison of mean nutritional analysis, nutritional quality was similar among rations (Table 3). All pens consumed the entire supplement offered each day (data not shown). Therefore, intake of supplement was not different among treatments (data not shown). Hay intake was not calculated as ewes were allowed to access *ad libitum*. Thus, only the individual bale weights were recorded to calculate the mean average that was distributed throughout the study.

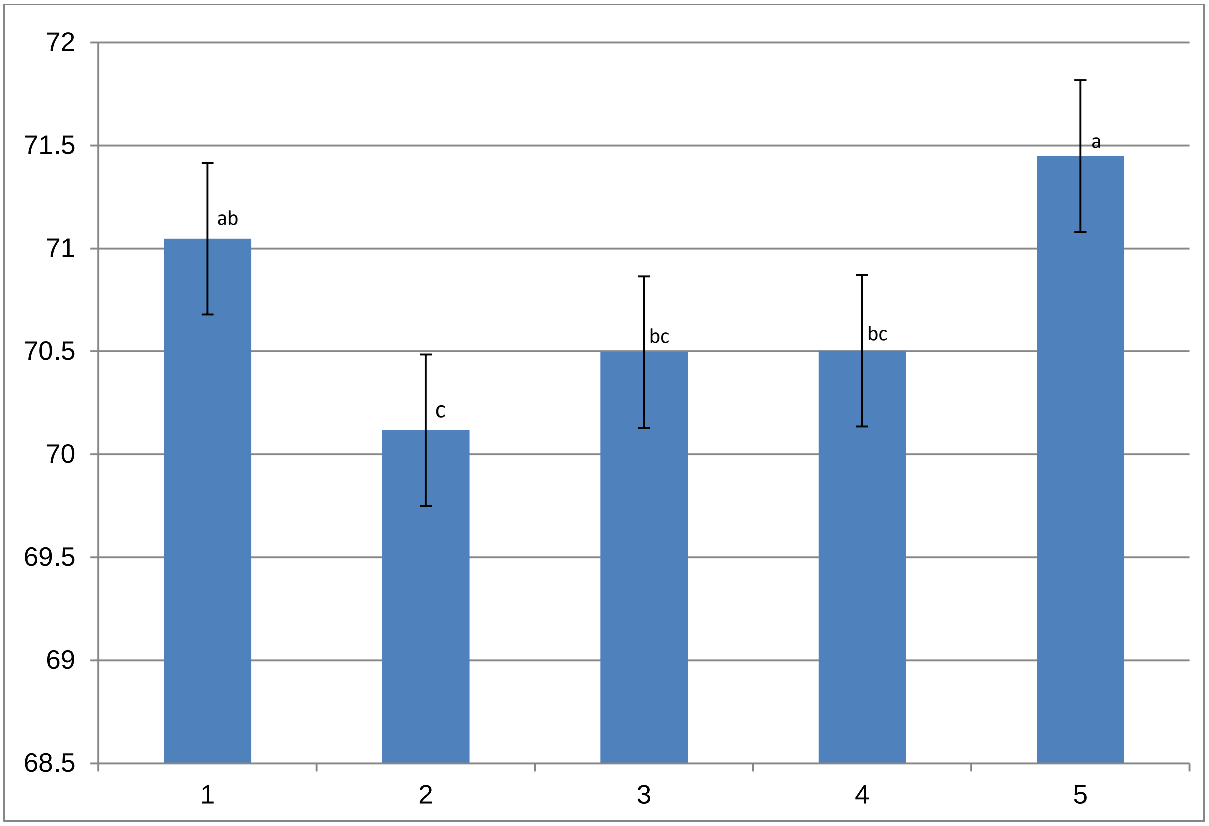
Mean body weights within all treatments differed ($P < 0.05$) by date (Figure 1). The lowest total mean sum of body weights was during the second weigh period while the highest was observed in the last weigh period at the conclusion of the study (Figure 1). Total mean body weights among treatments were similar ($P > 0.05$) (Figure 2).

Treatment by day interaction for weight differed ($P < 0.05$) (Figure 3). Ending body weights were heavier for all treatments receiving supplements. There were variations among total mean body weight between treatments receiving winter supplements. Although, initial mean body weight was highest in the 10% treatment, the final mean body weight was highest in the 30% treatment. In contrast, the 30% treatment better maintained and increased body weight over the 10 % group as well as the 0% treatment and control all while having a lower mean body weight by treatment (Figure 2).

Costs varied among the three supplemental rations because of variations in ingredients (Table 4). Costs varied from \$307.62, \$292.14, and \$284.41 for the rations containing 0, 10, and 30% CGF, respectively.

Table 3. Mean nutrient content of treatments containing varying levels of DCGF determined by laboratory national analysis.

| Nutrient (As Fed) | Hay | Percent DCGF In Treatment | | |
|---|---|---|---|---|
| | | 0% | 10% | 30% |
| | | ---%--- | | |
| Dry Matter | 92.4 | 91.8 | 91.8 | 91.6 |
| Crude Protein | 8.9 | 9.8 | 9.8 | 8.8 |
| Digestible Protein | 63.8 | 44 | 38.3 | 38.3 |
| Acid Detergent Fiber (ADF) | 35.9 | 47.2 | 47.2 | 46 |
| Neutral Detergent Fiber (NDF) | 59.9 | 65.9 | 65.9 | 62 |
| Total Digestible Nutrients (TDN) | 59.9 | 67 | 67 | 68.3 |
| NEm (kcal $\cdot kg^{-1}$) | 1.1 | 1.5 | 1.5 | 1.5 |




[abc] Values with the same superscript do not differ (P<.05)

Figure 1.Total mean difference in treatments body weights by date (Effect of dates interaction on body weight (kg) P < 0.05) over 60 day supplementation trials utilizing DCGF in winter supplement at 0, 10, 30%

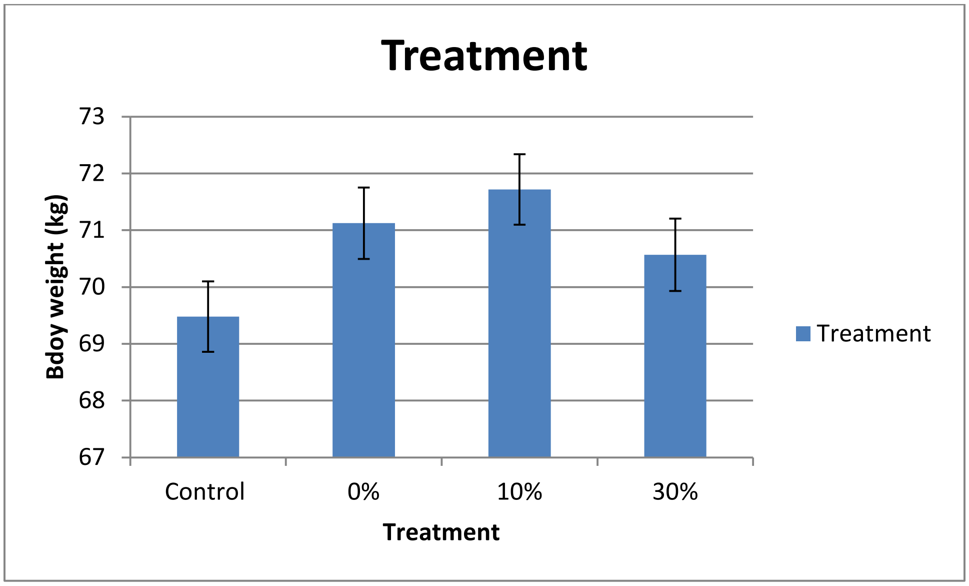



Figure 2. Total mean difference of body weights between treatments (Effect of treatments interaction on body weight $P > 0.05$) over 60 day supplementation trials utilizing DCGF in winter supplement at 0, 10, 30%

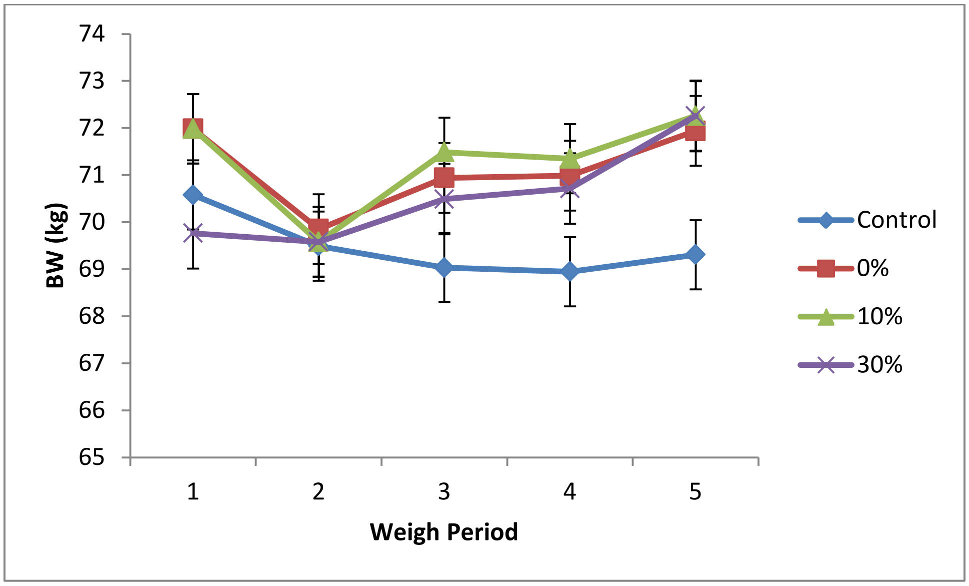



Figure 3. Weight means among treatments for each biweekly weight period (treatment x day interaction was significant P < 0.05) across 60 day supplementation trails utilizing DCGF in winter supplement at 0, 10, 30%

| Ingredients | Price ($cwt.) | Percent DCGF In Treatment | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0% | | 10% | | 30% | |
| | | Amount (kg) | Price/Ingredient | Amount (kg) | Price/Ingredient | Amount (kg) | Price/Ingredient |
| Corn | $9.01 | 173.3 | $34.42 | 213.6 | $42.44 | 96.2 | $19.10 |
| Cottonseed Meal | $17.78 | 566.9 | $222.25 | 556.7 | $217.80 | 491.7 | $192.74 |
| Alf Pellets | $15.30 | 264 | $40.39 | 0 | $0 | 0 | $0 |
| Corn Gluten | $10.67 | 0 | $0 | 90.7 | $21.34 | 272.2 | $64.02 |
| Molasses | $10.56 | 45.3 | $10.56 | 45.3 | $10.56 | 45.3 | $10.56 |
| Premix | - | 1.8 | - | 1.8 | - | 1.8 | - |
| Total | - | 907.2 | $307.62 | 907.2 | $292.14 | 907.2 | $284.41 |

Table 4. Total cost of treatments by ingredients per ton of supplement on an as fed basis.

## DISCUSSION

Unfortunately, the supplementation utilized throughout this study was mixed incorrectly. Rather than crude protein content being within the 30% range as formulated (Table 2) in all treatments it was exceptionally lowered. Laboratory nutritional analysis showed that mean crude protein was similar at 9.8 in the 0 and 10% treatments and 8.8 in the 30% treatment (Table 3). This error was caused when supplements were mixed prior to the study. Each treatment was mixed as formulated (Table 2) but rather than utilizing cottonseed meal at a rate of 62.5, 61.2 and 54.2 percent in supplements containing 0, 10 and 30% DCGF, cottonseed hulls were used.

Although, both cottonseed meal and cottonseed hulls are byproducts of cotton processing, they differ in nutritional content more specifically crude protein. Cottonseed meal is utilized as a protein source in feeds that generally contains 41-46% crude protein (NCPA 2002). Cottonseed hulls are a source of fiber in feeds and normally contain 5% crude protein (NCPA 2002). Therefore, the discrepancy in crude protein between formulated rations and actual ration was due to the use of cottonseed hulls rather than cottonseed meal.

Results of this study showed there was no difference in intake among treatments when consuming the supplementation containing 0, 10, or 30% DCGF. These results contrasts with results from previous research by Samuelson (2013), who found that lambs consuming a diet consisting of 20 and 30% DCGF consumed less than the control diet of 0%

DCGF. Although, a study by Firkins et al. (1985) illustrated intake was not different for lambs fed diets containing corn silage, DCGF or WCGF.

Little data is available concerning dry corn gluten feeds effect intake and gain in sheep as most studies are directed toward cattle and wet corn gluten feed. Accordingly, additional trials utilizing cattle by Firkins et al. (1985) show that intake was increased in diets containing DCGF over WCGF and Soy Bean Meal (SBM). Additionally, Parsons et al. (2007), Krehbiel et al. (1995) and Ham et al. (1995) showed that intake was increased in steers fed a diet containing WCGF at 40% over the control diet containing dry rolled corn (DRC). Kampman and Loerch (1989) also concluded that steers feed DCGF resulted in increased feed intake when used in corn silage or high-moisture corn (HMC) diets. However, additional trials by Firkins et al. (1985) showed a reduction in intake by steers fed WCGF. This reduction of intake may have been due to the mean particle size of WCGF (2 mm) as compared to DCGF (.9 mm) (Firkin et al. 1985; Blasi et al. 2001)). Therefore, a difference in particle size may affect the overall rate of passage and rate of digestibility of WCGF as compared to DCGF (Blasi et al. 2001). A study by Ham et al. (1995) also showed a decrease in intake when comparing WCGF to DCGF, which may have also been attributed to the particle size as well as moisture content of diets utilized and/or changes in fiber digestion within calves.

The results in this study showed no difference in intake which may be due to the amount of supplementation offered to each treatment group (1,028 g per pen) as compared to trials utilizing feedlot and/or finishing rations. This allowed ewes to consume the entire amount of supplement offered at each distribution period resulting in no refusals among treatments and thus showing no difference in intake among treatments.

Results of this study also show that treatment by date interaction was significant and was differed when mean body weights were compared between treatments by weigh period. Ewes fed the 30% treatment showed to have a linear effect on body weigh between each weigh period and out-gained the control, 0% and 10% treatment groups. The 30% treatment showed to have the lowest initial mean body weight but finished the trials with the highest mean body weight. Therefore, ewes fed the 30% treatment had the best rate of gain by weigh period all while having the lowest total mean body weight per treatment even though total mean body weight between each treatment was not significant.

These results agree with Kampman and Loerch (1989) which showed that feeding DCGF in silage-based diets increased cattle gains. Firkin et al. (1985) found that steers fed DCGF gained faster than steers fed WCGF and noted that steers fed WCGF diet as an average tended to gain faster than those steers fed control diets. Additionally, Hannah et al. (1990) found that the addition CGF to alfalfa hay improved rate of gain in steers fed diets contain 60% supplement over those consuming diets with 20% supplement. Krehbiel et al. (1995) showed that gain was maximized when WCGF replaced 40 of dry rolled corn in the diet. However, these results contrast with Samuelson (2013) who found no difference in weight gain and therefore average daily gain among treatments diets containing 0, 10, 20 or 30% DCGF. Additionally, Samuelson's results agree with Firkin et al. (1985), Ham et al.

(1995) as well as Macken et al. (2004) who all showed no difference in average daily gain when feeding DCGF or WCGF in finishing diets with steers.

The results of this study are confounded due to the error made when mixing the supplement used for the entire study. Therefore, the differences in body weights and gains among the control, 0, 10 and 30% treatments may be due to differences in crude protein among treatments. Therefore, if each treatment were mixed properly and as formulated gains may not differ and therefore may agree with previous research done at Angelo State University results from Sameulson (2013).

This study also indicates that utilizing dry corn gluten feed in winter supplements is economically feasible and cost efficient if animal performance is similar among supplement types. Therefore, dry corn gluten feed may potentially decrease overall input cost through decreasing total cost of supplementation provided to livestock. Although, supplements fed within in the study was mix inappropriately. An evaluation of current cost of ingredients utilized within the treatments showed livestock producers could potentially save $23.21 per ton by providing supplements containing 30% DCGF. Total cost of supplements used in this study containing 0, 10 and 30% DCGF was $307.62, $292.14 and $284.41 (Table 4). Sameulson (2013) also noted by providing rations containing 30% DCGF livestock producers could save $6.25 per metric ton of feed. Additionally, an economic evaluation by Haugen and Hughes (1997) showed that feeding WCGF is not only economically feasible but was profitable.

# IMPICATIONS

The use of DCGF in winter supplements did not appear to cause undesirable effects on ewe's performance. The utilization of DCGF in these supplements did not show a difference in intake but did appear to maintain and increase body weight. Unfortunately, due to the issue causes by the error of mixing the supplement used within this study at all levels of treatment conclusions are somewhat limited. Therefore, the limited amount of data on the subject matter as well as the error within this study suggests that further research is warranted to determine if utilizing corn gluten feed in winter supplements for sheep is feasible. Due to the current high prices of winter supplements utilizing DCGF may be a viable option for producers to maintain body weight and condition within livestock will decreasing the overall cost.

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